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European Association of National Metrology Institutes

TC for Time and Frequency

Highlights and Challenges

Andreas Bauch, TC-TF Chair, PTB

Ramiz Hamid, TC-TF Incoming Chair, UME

7nd EURAMET General Assembly

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OUTLINE

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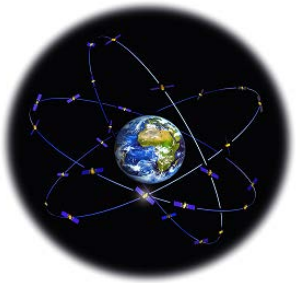
Introduction

30 institutes in TC-TF
In 2012 and 2013 new delegates:Belgium, Macedonia, Montenegro and Spain

32 insitutes from EURAMET member support the generation of UTC an TAI

NPL, LNE-SYRTE and PTB contributed to TAI with their PFS, and the second is realized with an uncertainty less than one part in 10^{15}

The European Satellite Navigation System Galileo has passed major steps towards its completion, with time and frequency services built on contributions from EURAMET NMIs.



Comparison and GNSS receiver calibration activity in progress (NMI+BIPM)

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EMRP Projects

2010 call:

IND14, New generation of frequency standards for industry

2011 call:

SIB02, Accurate time / frequency comparison and dissemination through optical telecommunication networks

SIB04, High-accuracy optical clocks with trapped ions

2012 call:

IND55, Compact microwave clocks for industrial applications

SIB55, International timescales with optical clocks

SIB60, Metrology for long distance surveying

EXL01, Quantum engineered states for optical clocks and atomic sensors

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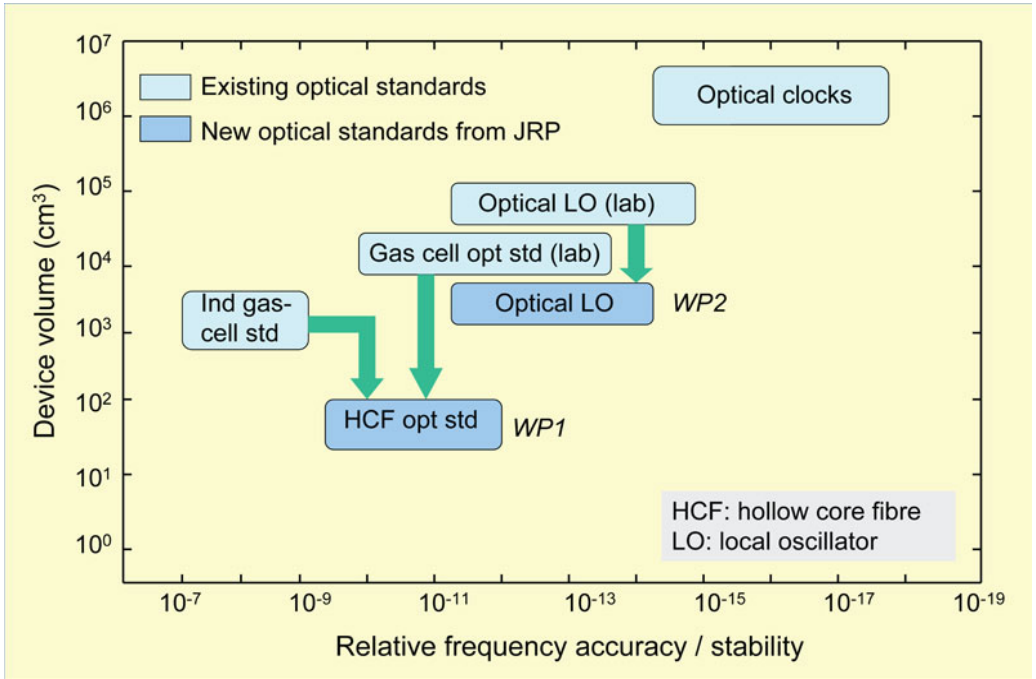
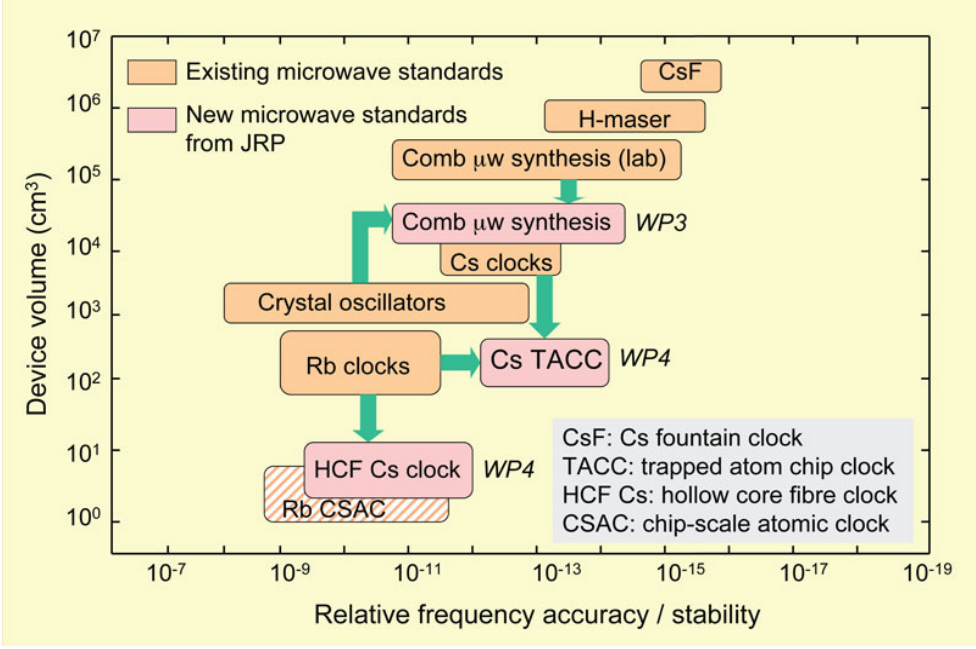
IND14, New generation frequency standards for industry

- JRP Coordinator: Patrick Gill, NPL
- Duration 3 years, started August 2011
- Aim: Transform NMI-based standards into compact, robust and turn-key standards for industrial applications
- Sectors: Telecoms, aerospace, navigation, defence and security
- Output: Optical and microwave frequency standards

WP1: New compact hollow-fibre-based optical wavelength standards,
WP2: Compact, vibration-insensitive and transportable optical local oscillators
WP3: Low noise microwave synthesis from compact optically-referenced fs combs
WP4: Atom-referenced microwave standards
Key Deliverable:
Robust and compact optical source with a frequency instability of 5×10^{-15} at 1 – 100 s
Microwave standards with frequency stability and accuracy in the 10^{-10} - 10^{-13} range





IND55, Compact microwave clocks for industrial applications

- JRP **Coordinator**: S. Micalizio, **INRIM**
- **Partners**: UME (TR), SYRTE (FR), UFC (FR), Université de Neuchatel (UniNe-LTF), Switzerland, CNRS (FR)

This JRP is supported by the following **stakeholders**:
Spectratime, DGA, CNR, Spectracom, Thales Electron Devices SAS, Thales R&T, CSEM, METAS, Selex Galileo, Italian Space Agency (ASI)

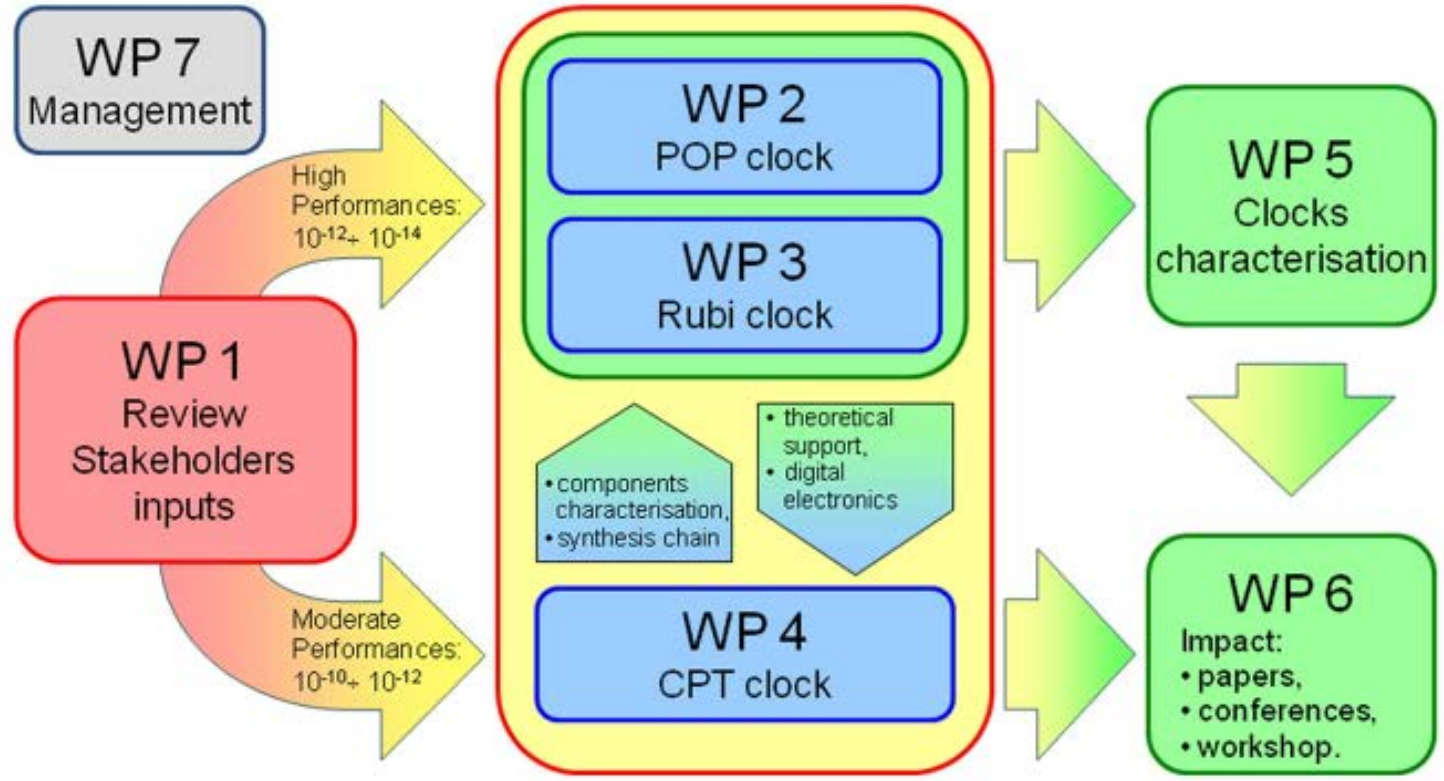
- **Duration** 3 years, started 2013
- **Aim**: Development reliable and hand-held standards for wide industrial applications
- **Sectors:** Telecommunication networcs, satellite navigation, research
- **Output:** development of compact and high-performing microwave clocks based on the vapour-cell technology

Key Deliverable:

Robust and compact, optimizing size, reliability and suitability to operate in industry

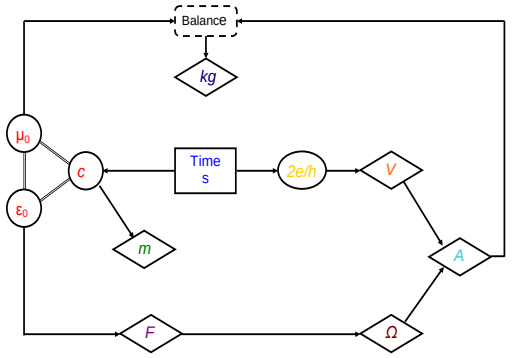
To offer better accuracy

Realization of hand-held clock with frequency stability in range 10^{-10} - 10^{-12} at 1 s



SIB02, Accurate time/frequency comparison and dissemination through optical telecommunication networks,
Investigation of new techniques for phase coherent comparison of optical clocks, separated by distances of up to 1500 km using optical fibre links

SIB04, Ion Clock - High-accuracy optical clocks with trapped ions
Development of ultra - precise optical clocks
using laser - cooled trapped ions.
Improvement of Second is important
for "**m**", "**V**" and "**A**"



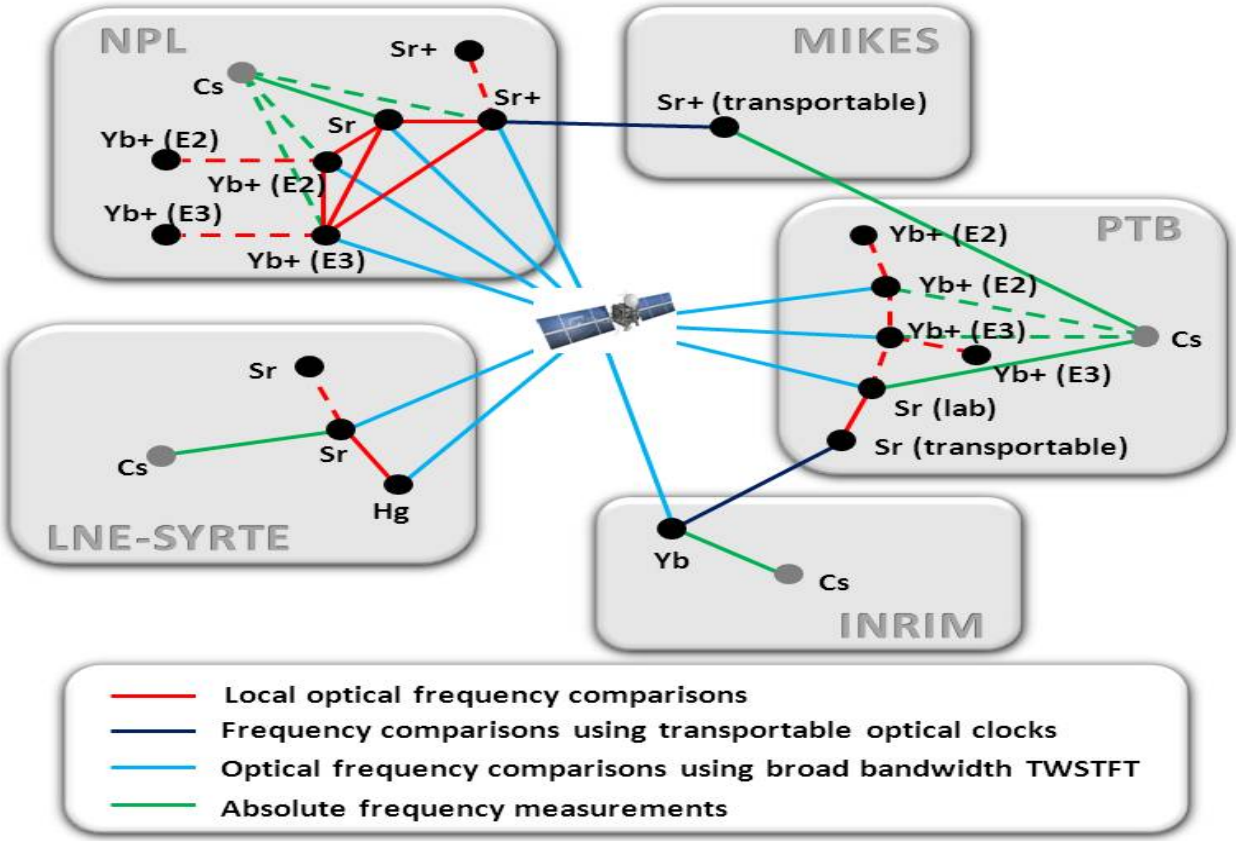
SIB60 Surveying: Metrology for long distance surveying,
Improvement and comparison of distance measurement
by laser and GNSS receivers with mm uncertainty, traceable to definition of "m"

EXL01, QESOCAS - Quantum engineered states for optical clocks and atomic sensors,
Limits: fequency noise of the laser and quantum projection noise.
Investigation for towards uncertainties **at the 10^{-18} level**

SIB55, International Timescales with Optical Clocks

- JRP **Coordinator**: Helen Margolis, NPL,
  Partners: CMI (CZ), PTB (DE), MIKES (FI), LNE (FR), OBSPARIS (FR), INRiM (IT), LUH(DE), CNRS (FR), UPMC (FR)
- **Duration** 3 years, started 2013
- **Aim:** Tackle key challenges before any future optical redefinition of the second
- **Sectors**: International metrology community
- **Output:** The possibility of a future redefinition of the second in terms of an optical transition frequency

WP1: Local frequency comparisons and absolute frequency measurements,
WP2: : Frequency comparisons using transportable optical clocks
WP3 : Relativistic timescales and geodesy experiment
WP4: Remote clock comparisons via satellite links and analysis for timescale



Key Deliverable:
Comparison at 10^{-17} - 10^{-16} level,

Future optical redefinition of the second

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Thank you for your attention!